Viewer Symptoms & Preferences
- Comparing 3D TV displays

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A research consortium supporting
"Quality Sustainable Vision"

Different TV Technologies

Quality vs. Comfort
Can we have both?

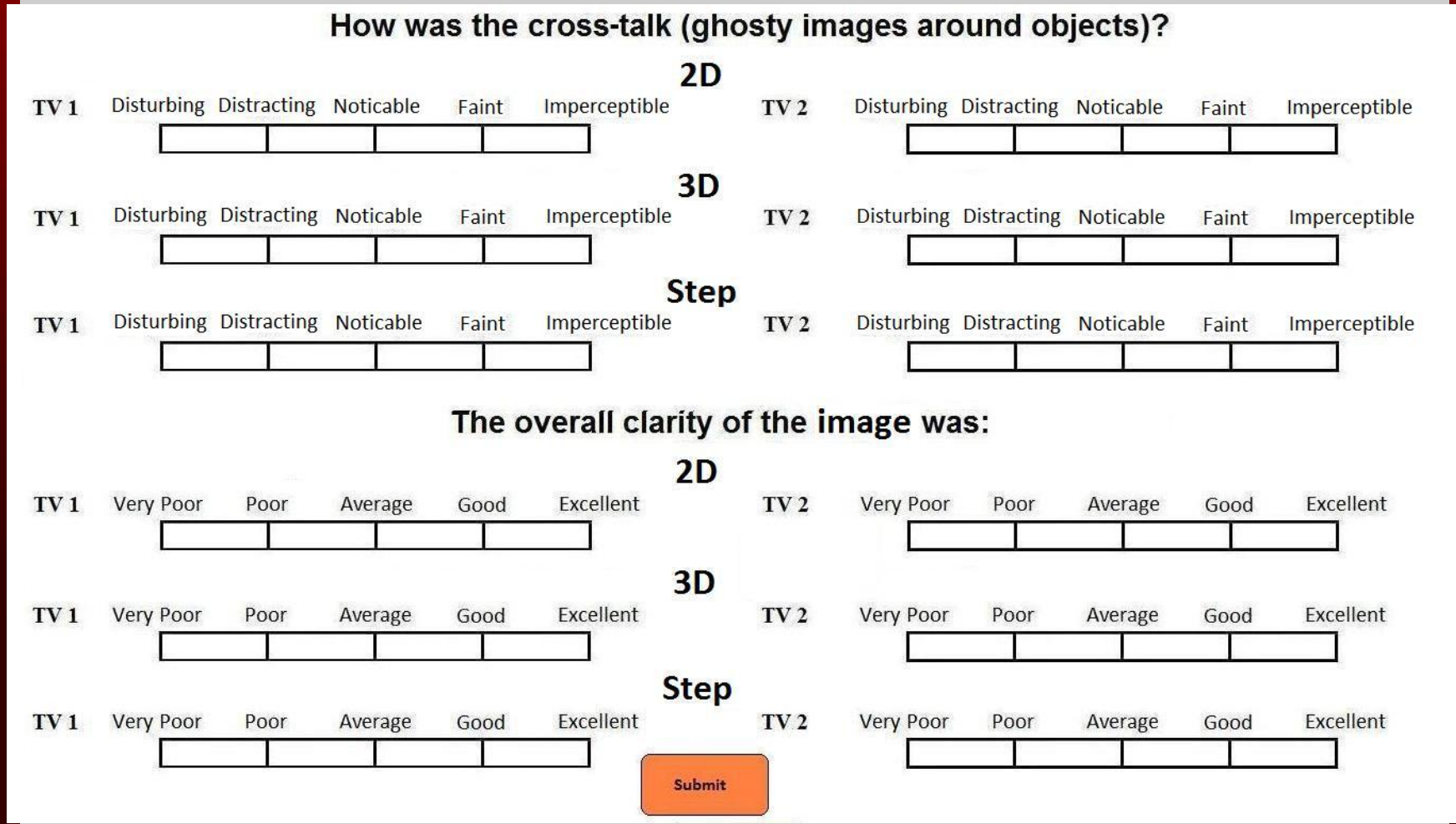
Study Design

- 3D TVs (55”, 1920 x 1080, 120Hz)
  - Samsung 55D7000
  - LG 55LW6500
- N = 60
  - 19 M, 41 F
  - 18-36 yr old, avg. = 24.23
  - VA 20/25 or better for both eyes
  - SA better than 60” (most 20” ~ 40”)

Procedures

- Visual Acuity Threshold,
  - 2D and 3D Landolt C
- Contrast Sensitivity Threshold,
  - 2D and 3D Landolt C
- Step-Vergence:
  - Ability to quickly fuse convergent or divergent image
- Stereo Acuity Threshold
  - WIRT dot diamond
- Depth Perception/Float Localization
- Subjective Questionnaires:
  - 2D vs small and large 3D image quality
  - Pre- and post- moving viewing discomfort
  - Side-by-side TV comparison

Image Quality Questionnaire 1



Visual/body discomfort questionnaire pre/post movie viewing

(100 severe discomfort)

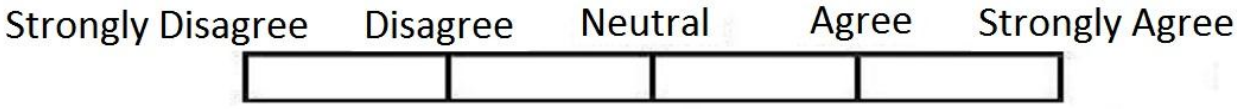
- My eyes felt tired
- My eyes felt irritated or had a burning sensation
- My eyes felt strained or it felt like there was a pulling sensation around my eyes
- I felt eye ache or pain inside of my eyes
- My eyes were dry or watery
- I experienced blurry vision
- I saw multiple images (double vision)
- I saw images move, jump, or swim on the screen
- I felt fatigue or sleepiness
- I had difficulty switching focus between near and far
- I experienced a headache
- I experienced dizziness
- I felt disoriented or had a sense of vertigo
- I experienced nausea
- I had neck discomfort
- I experienced general physical discomfort

(100 highly immersed)

- The object look real as they move through space
- I felt like I was part of the movie
- I felt engaged in the movie I viewed
- I lost track of time while viewing the movie
- I feel I can watch this TV for a long time

Questionnaire Example

The objects look real as they move through space



Side-by-side TV Comparison questionnaire (0: poor/disturbing -- 100: excellent/imperceptible)

General display quality (in 3D mode):

- The color displayed were…
- How was your perception of jagged edges?
- How was the cross-talk (ghost images around objects)?
- The display flickering was…
- The overall clarity of the 3D was…

3D presentation display quality

- The perception of depth was…
- The perception of motion smoothness was…
- What was your sense of immersion?

Viewing comfort (in 3D mode):

- The viewing angle was…
- Satisfaction with a tilted head position?
- The weight of the glasses was…
- The edges of the glasses frames were…
- Your overall satisfaction of the glasses is…

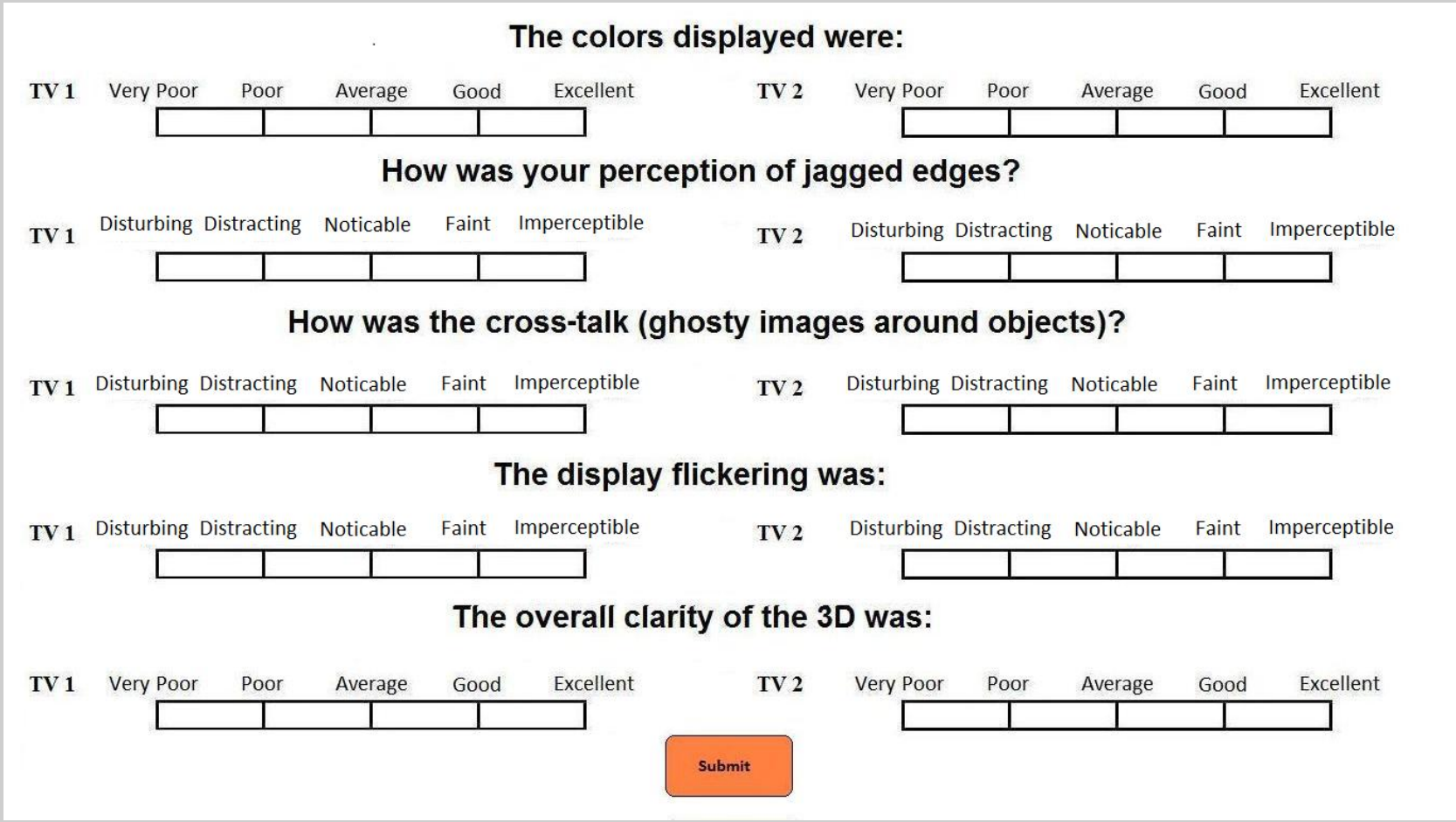
Tolerance (in 3D mode):

How long do you think you can watch this TV without feeling discomfort?
(none, little, some, a lot, infinite)

Preference:

Final television preference: (TV1 vs. Neutral vs. TV2)

Example:
Side-by-side TV comparison



The perception of depth was:

TV 1 Very Poor | Poor | Average | Good | Excellent

TV 2 Very Poor | Poor | Average | Good | Excellent

The perception of motion smoothness was:

TV 1 Very Poor | Poor | Average | Good | Excellent

TV 2 Very Poor | Poor | Average | Good | Excellent

What was your sense of immersion?

TV 1 Very Poor | Poor | Average | Good | Excellent

TV 2 Very Poor | Poor | Average | Good | Excellent

Submit

The viewing angle was:

TV 1 Very Poor | Poor | Average | Good | Excellent

TV 2 Very Poor | Poor | Average | Good | Excellent

Satisfaction with a tilted head position?

TV 1 Very Poor | Poor | Average | Good | Excellent

TV 2 Very Poor | Poor | Average | Good | Excellent

The weight of the glasses were:

TV 1 Very Poor | Poor | Average | Good | Excellent

TV 2 Very Poor | Poor | Average | Good | Excellent

The edges of the glasses frames were:

TV 1 Disturbing | Distracting | Noticeble | Faint | Impercepitable

TV 2 Disturbing | Distracting | Noticeble | Faint | Impercepitable

Your overall satisfaction of the glasses:

TV 1 Very Poor | Poor | Average | Good | Excellent

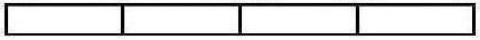
TV 2 Very Poor | Poor | Average | Good | Excellent

Submit

How long do you think you can watch this TV without feeling discomfort?

TV 1

None Little Some A lot Indefinitely



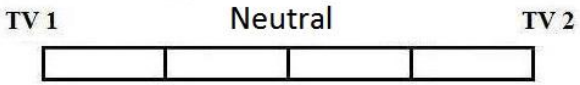
TV 2

None Little Some A lot Indefinitely

Submit

Final Preference

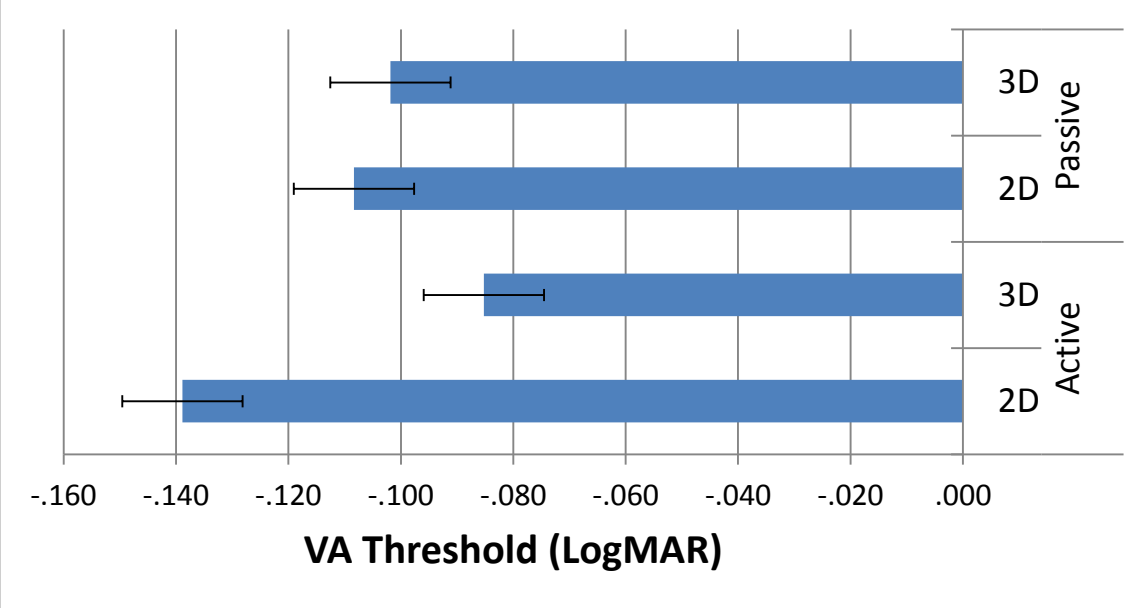
Final television preference:



Submit

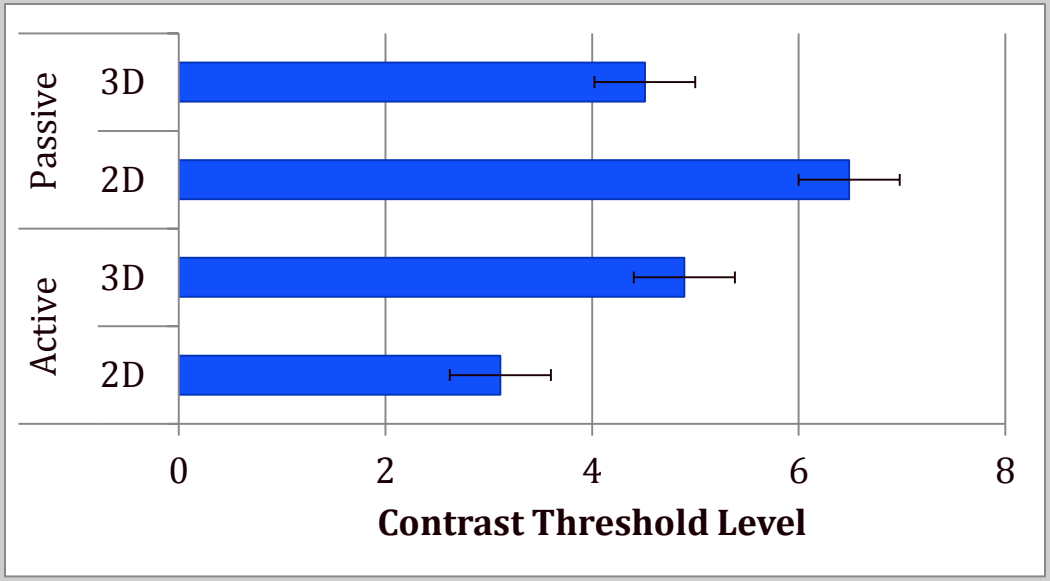
Visual Acuity (Landolt C)

- 2D > 3D
- Mode x TV:
  - 2D: Active better than Passive
  - 3D: n.s.
  - Active: 2D > 3D
  - Passive: n.s



Contrast Threshold:
Low contrast Landolt C

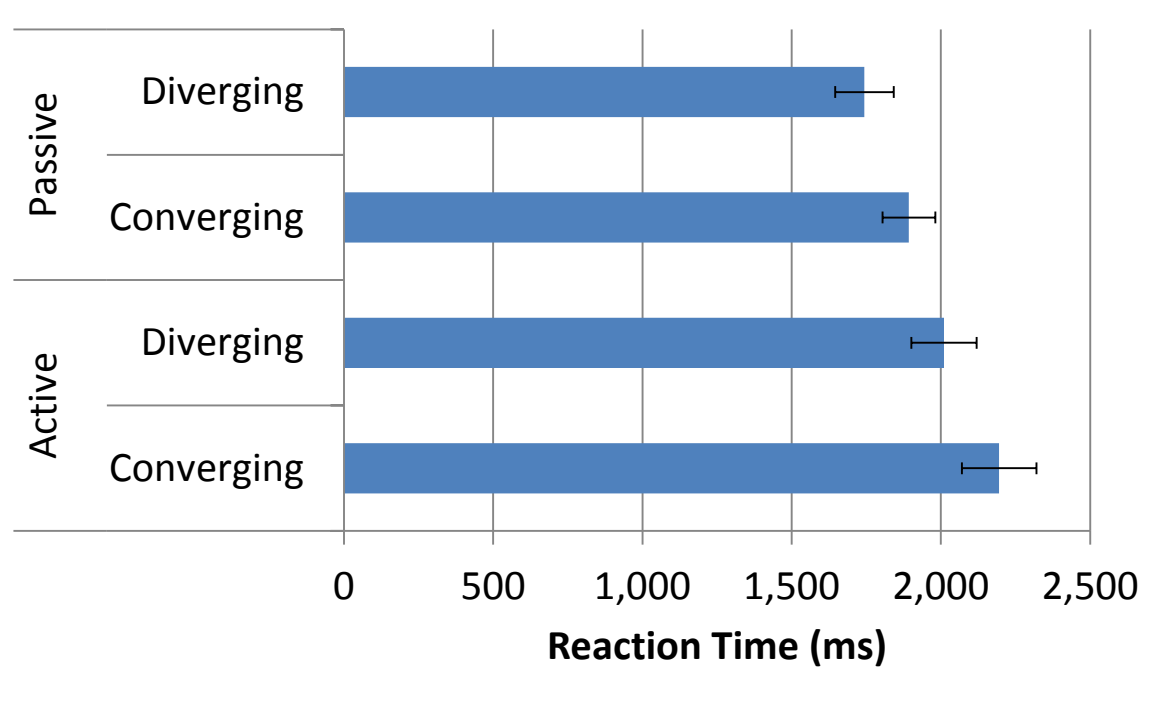
- **Threshold contrast level:**
  - **2D: Active better than Passive**
  - **3D: n.s.**
  - **Active: 2D > 3D**
  - **Passive: 3D > 2D**



Step-Vergence Test Accuracy

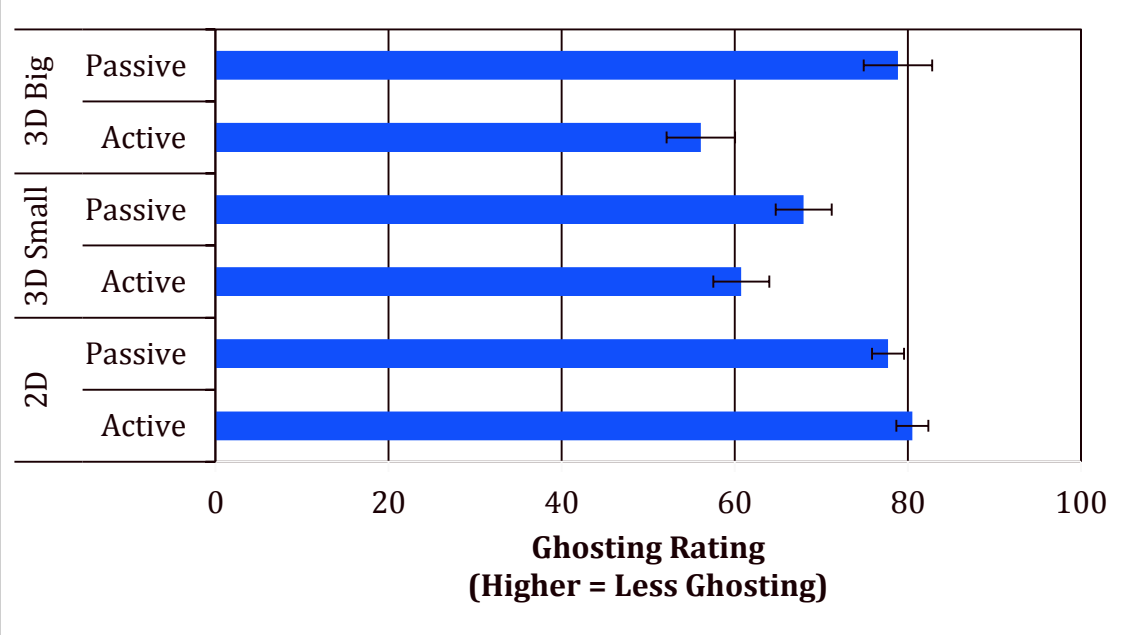
(Wirt 4 Dot with alternate convergence-divergence displays)

- **Overall: faster response switching time in passive system**



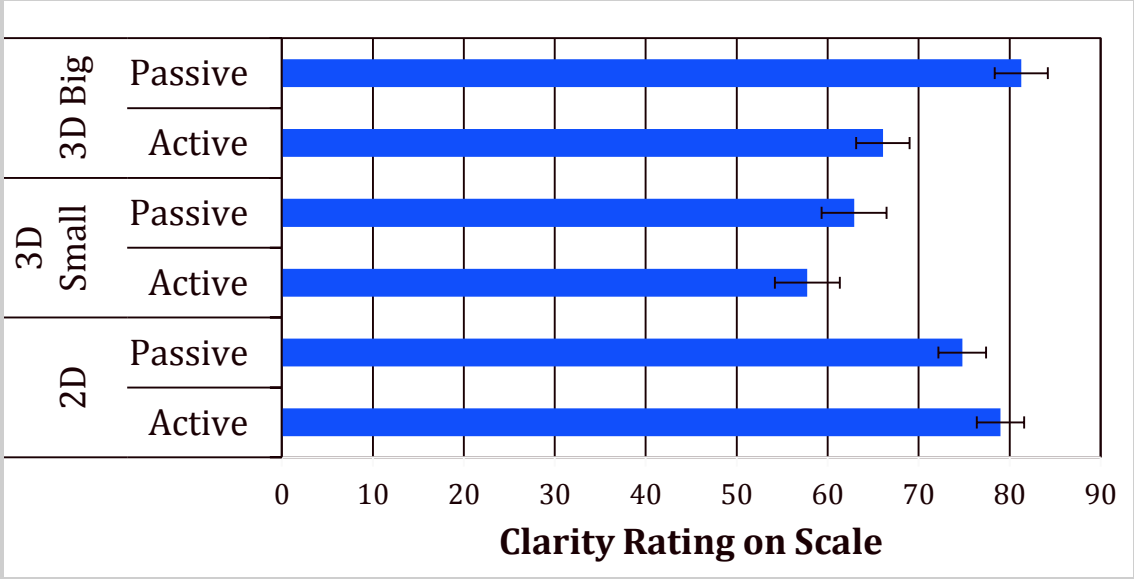
Display Quality Assessment: Ghosting

- Noticeable Ghosting
  - Larger ratings = less noticeable ghosting (better image quality)
  - See Ghost Image in 3D more than in 2D
  - 3D images: less ghosting on passive TV
  - 2D image: n.s.
  - Interaction:
    - Active: exist, regardless of image size
    - Passive: Perceived in small image, but not in large image



Display Quality Assessment: Clarity

- Image Clarity
  - 3D: Large 3D better on passive; n.s. for small 3D
  - 2D: n.s.
  - Interaction:
    - Active: 2D > large 3D image > small 3D image
    - Passive: large 3D image > 2D > small 3D image



No statistically significant differences between TVs:

- **Pre- vs Post- Movie Viewing: No difference on any symptoms or factors**
- **Stereo Acuity Levels**
- **Depth Perception/Float Localization**

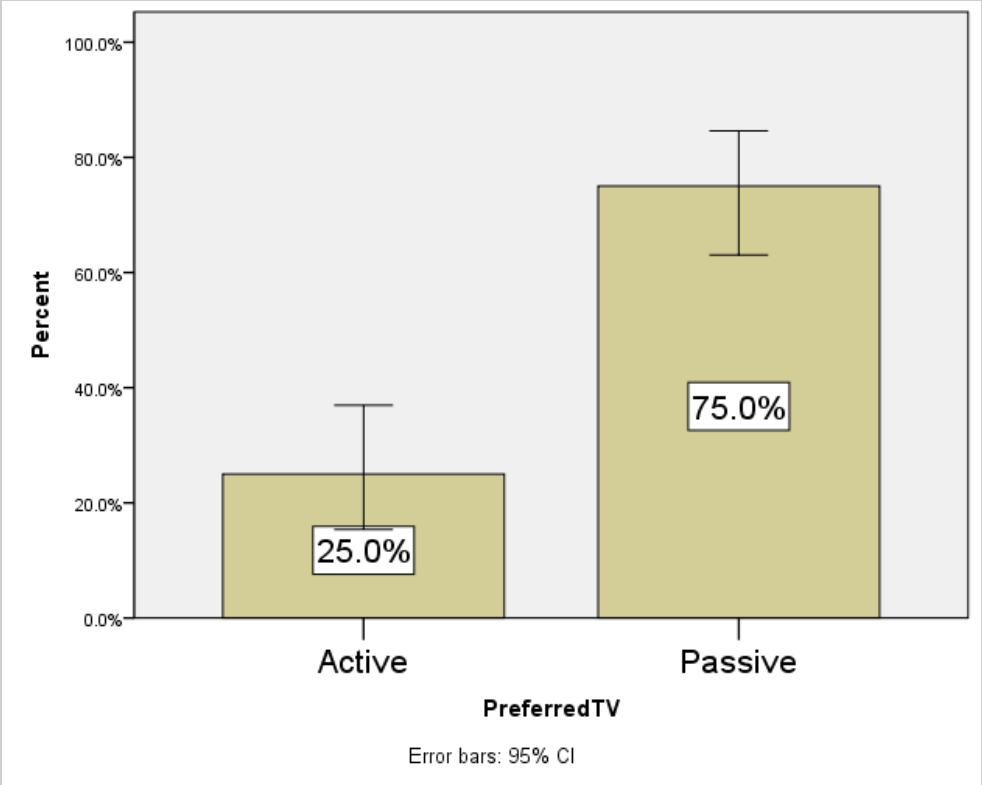
Side by Side comparison

- **Active: n.s. rating preferences**
- **Passive preferences:**
  - **Color**
  - **Clarity**
  - **Motion Smoothness**
  - **Immersion**
  - **Viewing Angle**
  - **Viewing Time**

Side by Side Comparison

- **Glasses: Passive**
  - **Overall preferred glasses**
  - **Lighter weight**
  - **Frame edge less disruptive**

Final TV Preference: Passive TV



Results Summary

Active	Passive
•Contrast Threshold in 2D •VA Threshold in 2D	•Final TV preference •Subjectively rated with better: color, clarity, motion smoothness and immersion •Preferred glasses (weight and frame edge) •Less disrupted by head tilt and viewing angle •Longer viewing time before discomfort subjectively predicted •Contrast threshold better in 3D •Faster vergence reaction times